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(54) **AIRCRAFT HUMIDIFIER**

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B64D 13/06 (2006.01)
B64D 11/00 (2006.01)

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CPC ***B64D 13/06*** (2013.01); *B64D 11/0007* (2013.01); *B64D 2013/064* (2013.01);
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See application file for complete search history.

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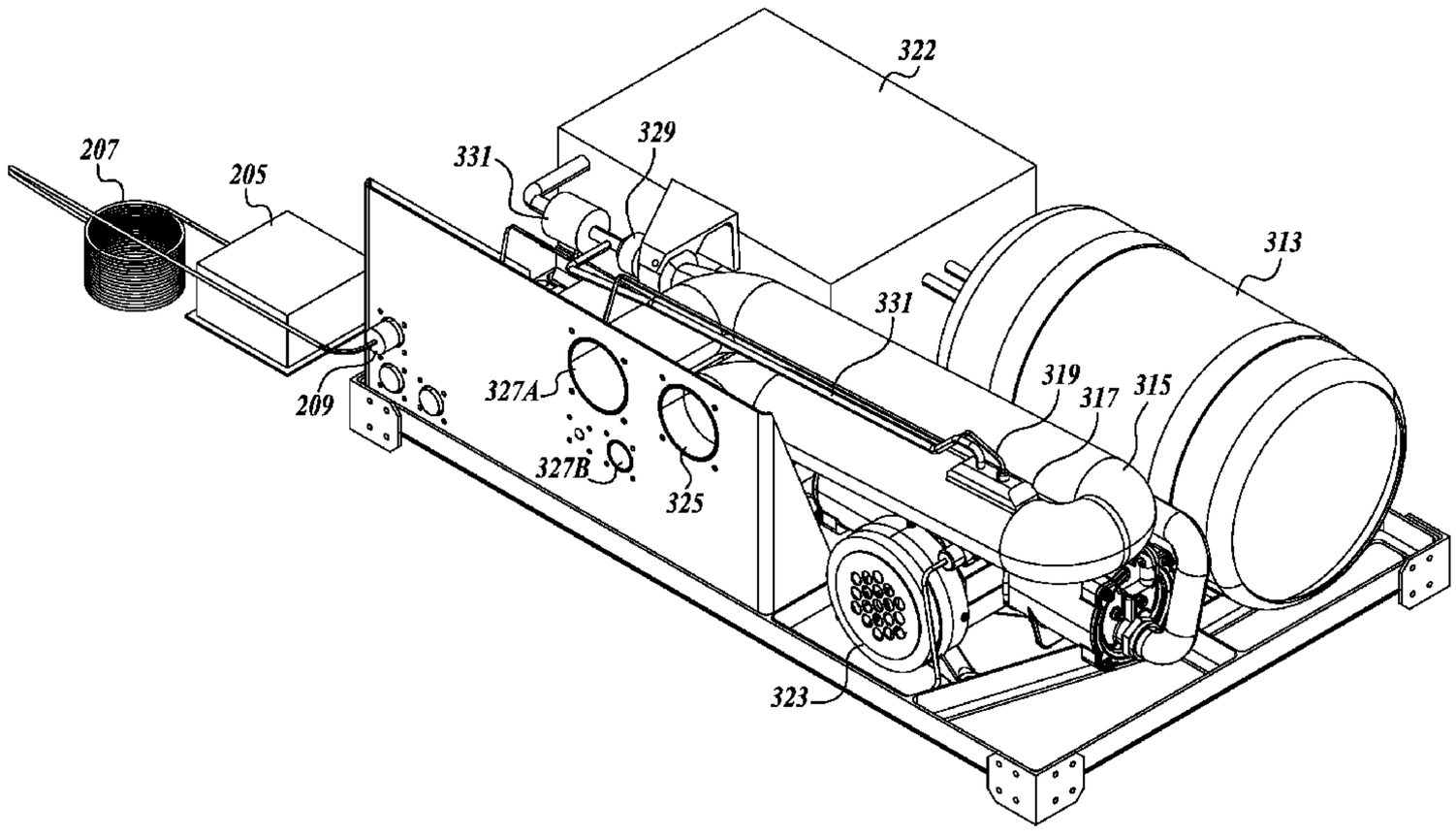
(57) **ABSTRACT**

An aircraft humidifier is engineered as a stand-alone, fully integrated aircraft humidifier that is suitable for providing uniform, non-wetting humidified air disbursed by the aircraft humidifier into ambient air to increase the relative humidity in low humidity environments such as aircraft interiors, including cockpits, cabins, crew rests, cargo holds, and lavatories as well as any other enclosed areas.

9 Claims, 15 Drawing Sheets



(52) **U.S. Cl.**
CPC *B64D 2013/0625* (2013.01); *B64D 2013/0651* (2013.01); *B64D 2013/0662* (2013.01); *B64D 2013/0666* (2013.01); *B64D 2013/0674* (2013.01); *B64D 2013/0688* (2013.01)

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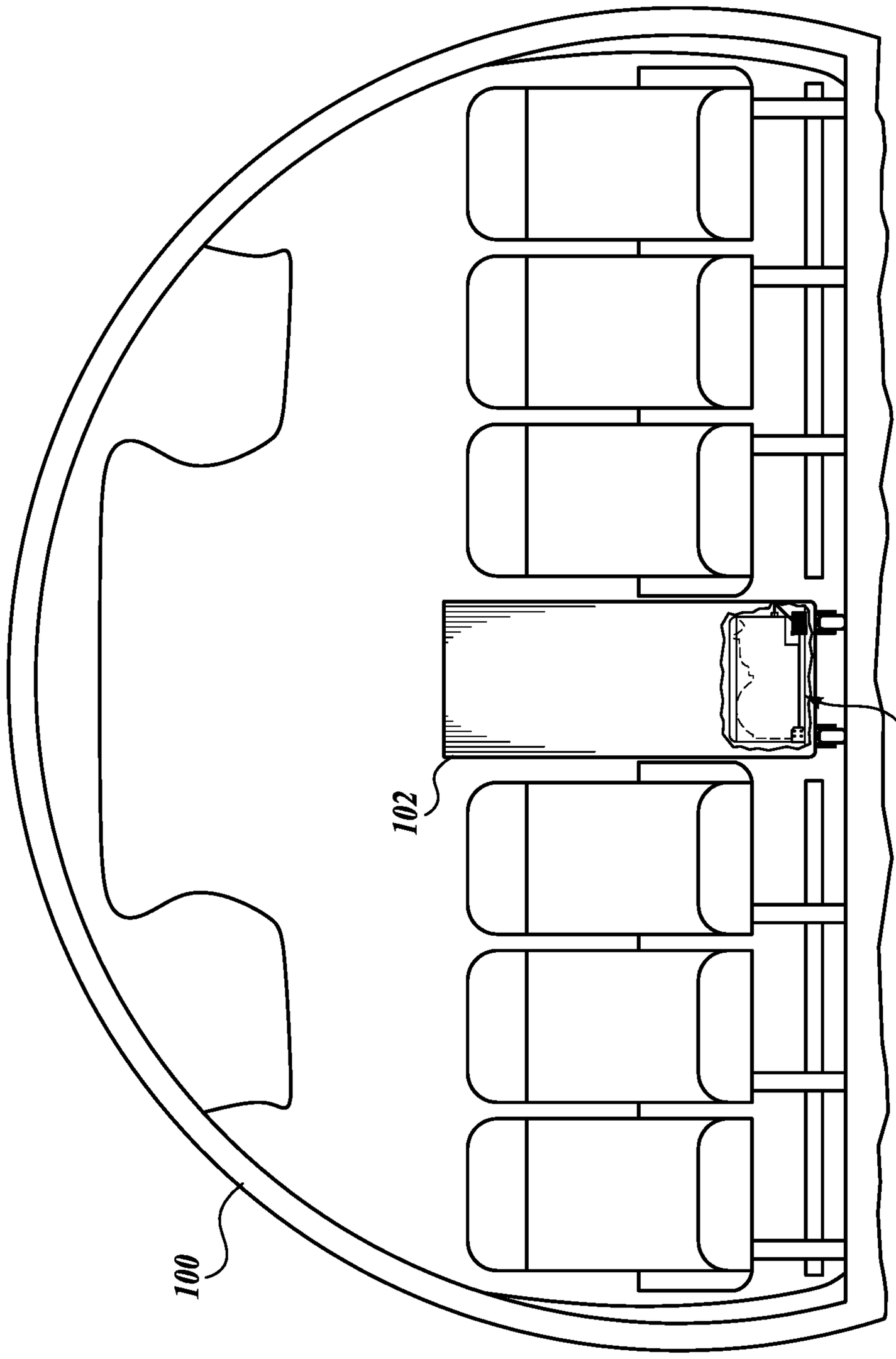


Fig. 1

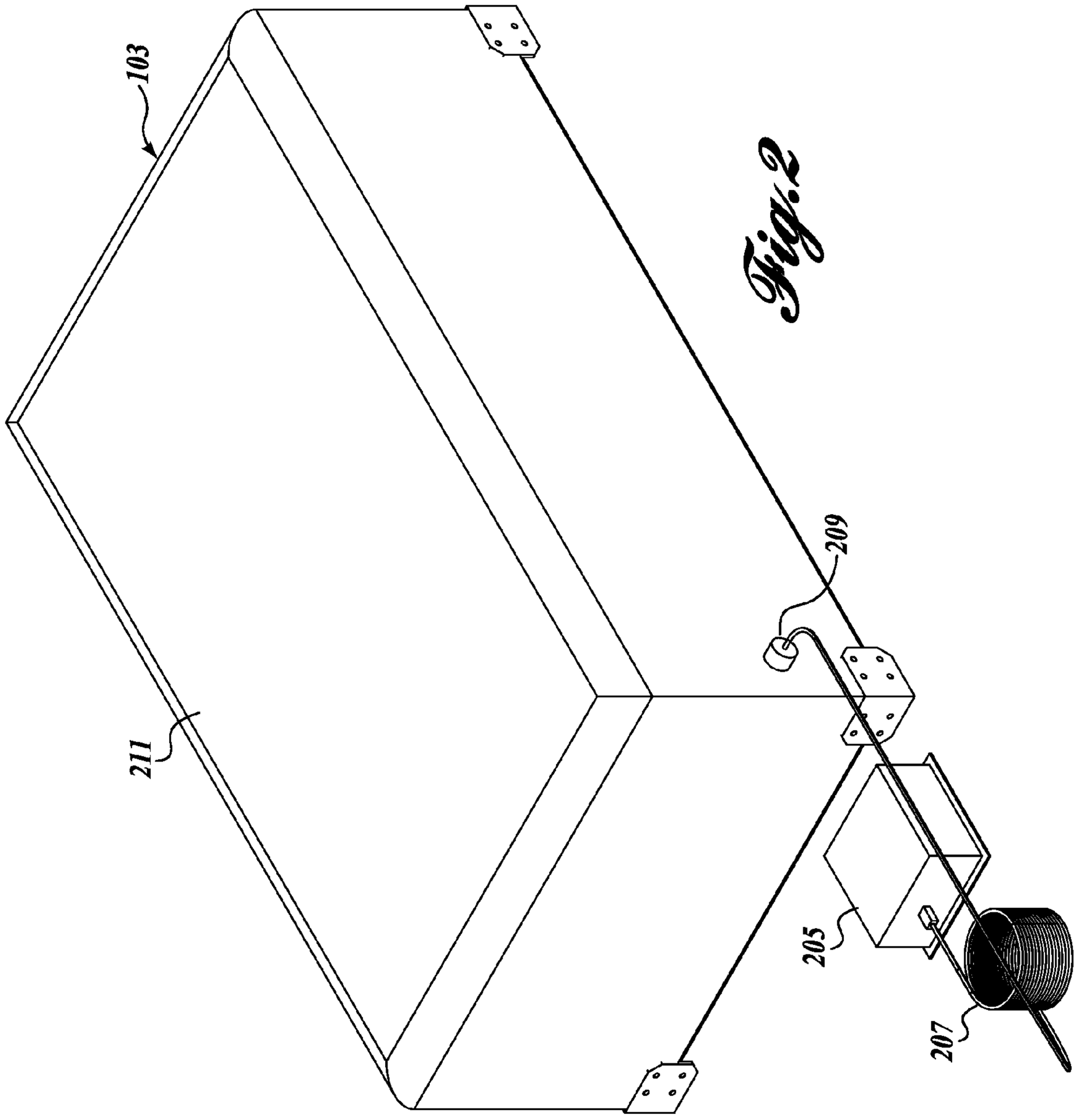


Fig. 2

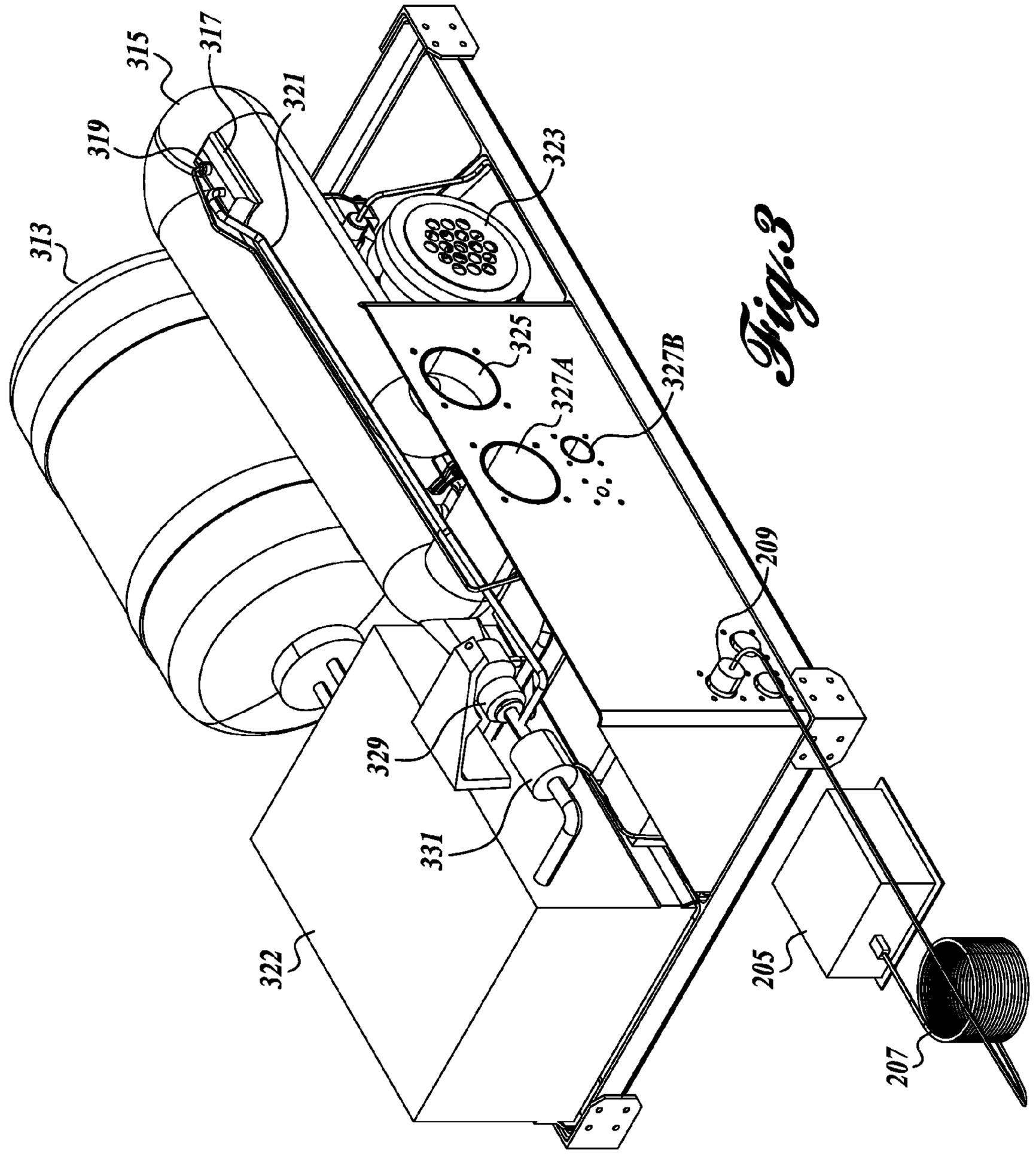


Fig.3

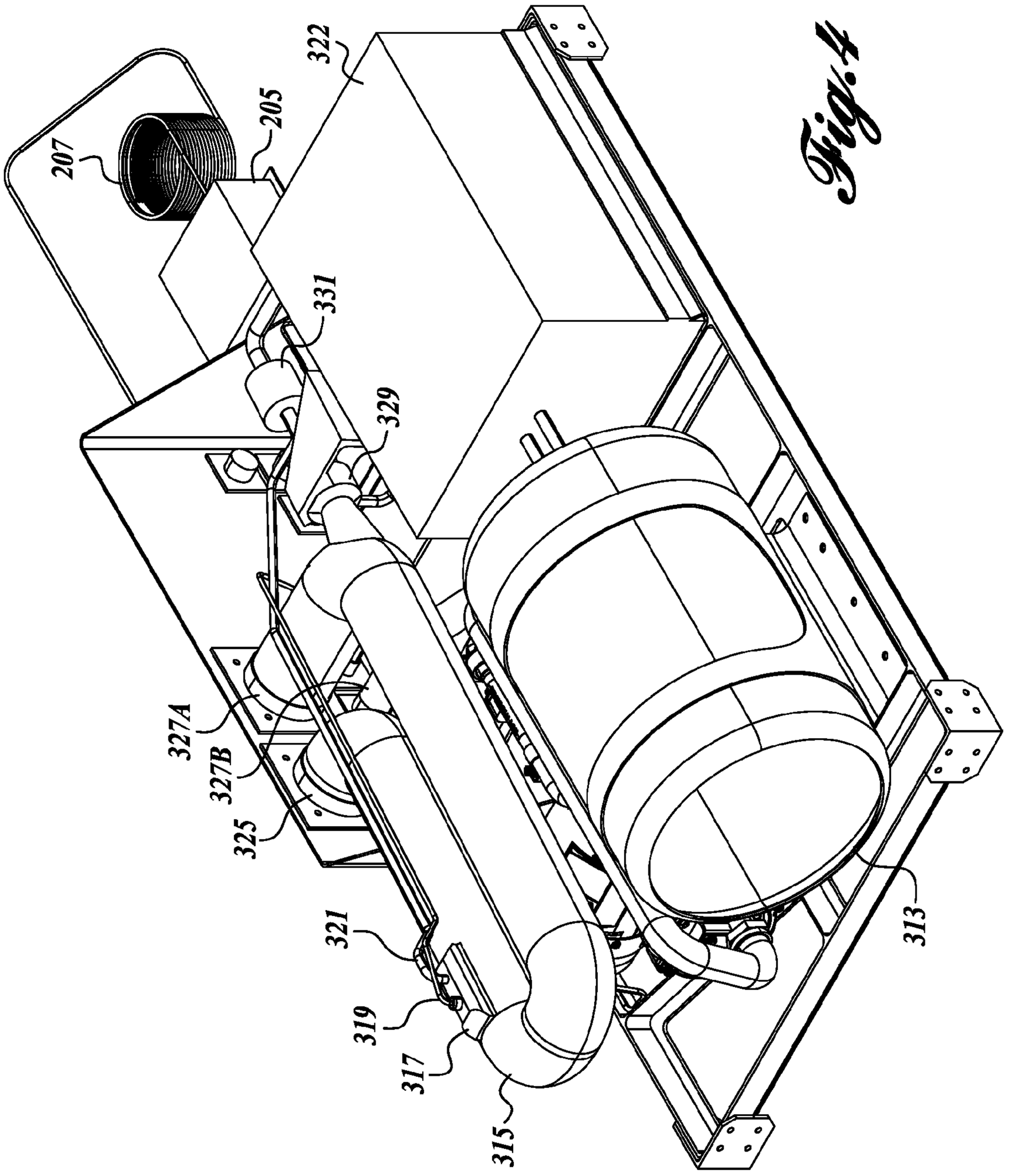
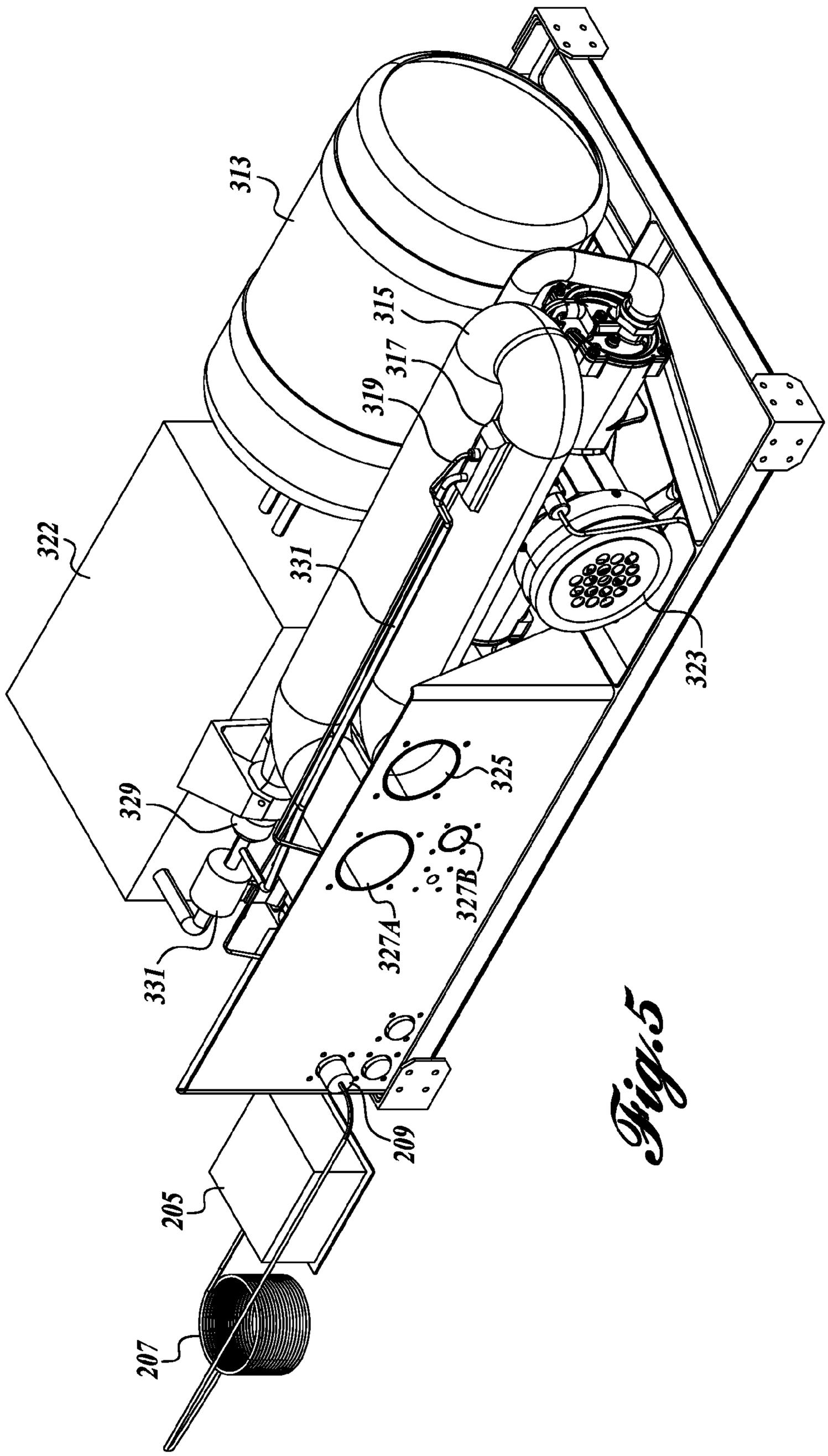


Fig. 4



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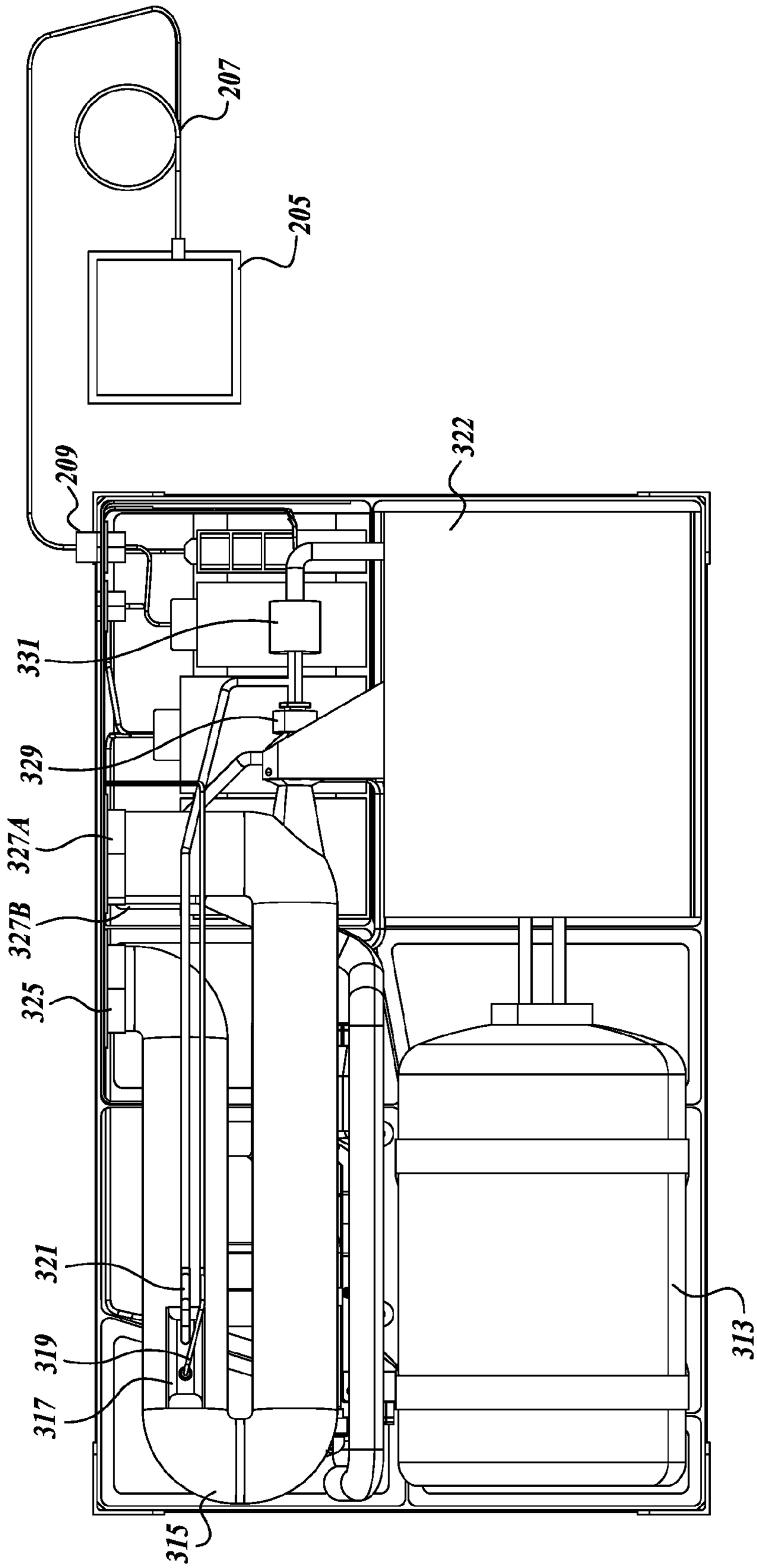
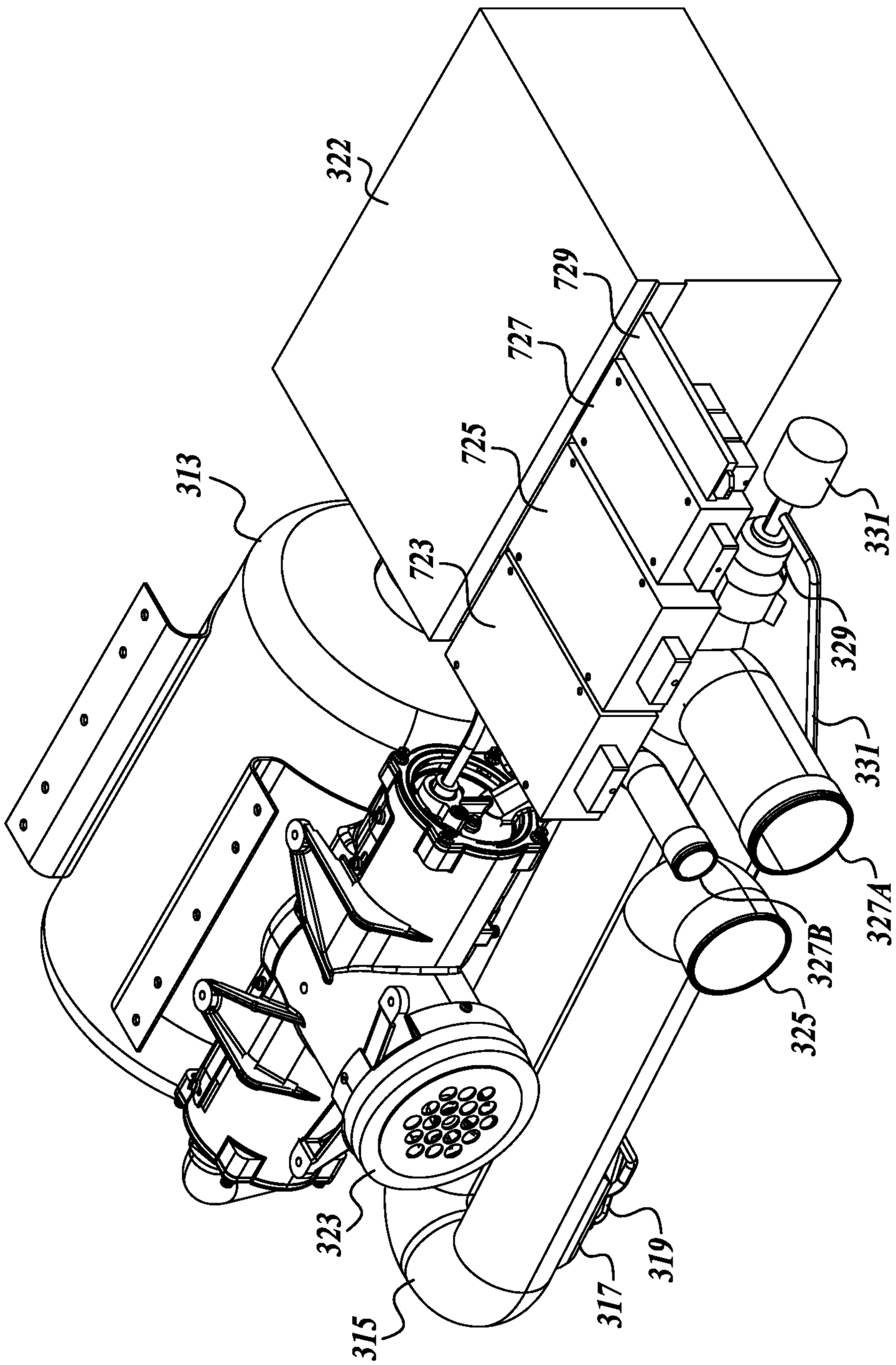


Fig. 6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729
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725
313
723
331
329
331
327A
327B
325
323
315
317
319

Fig. 7

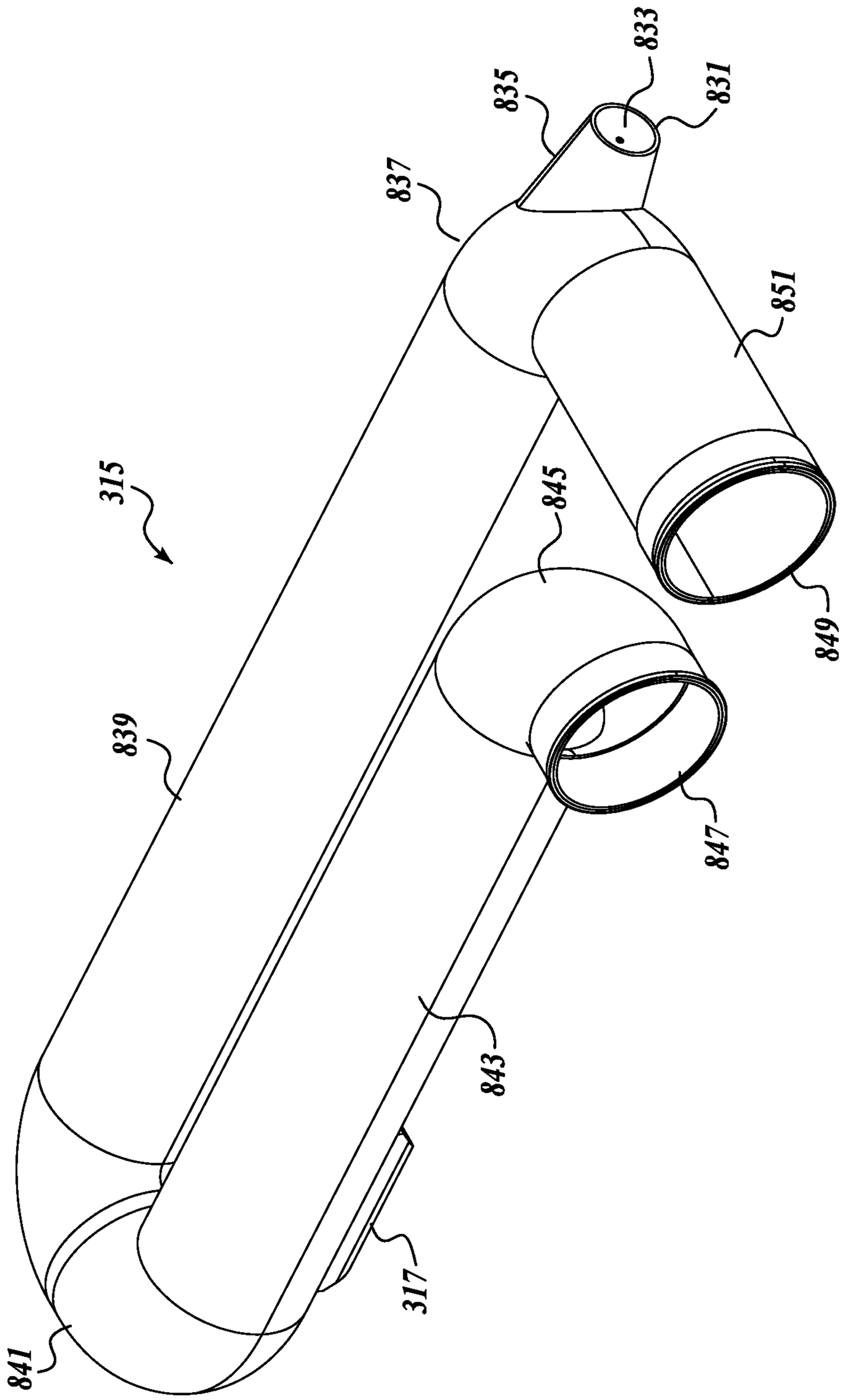


Fig. 8

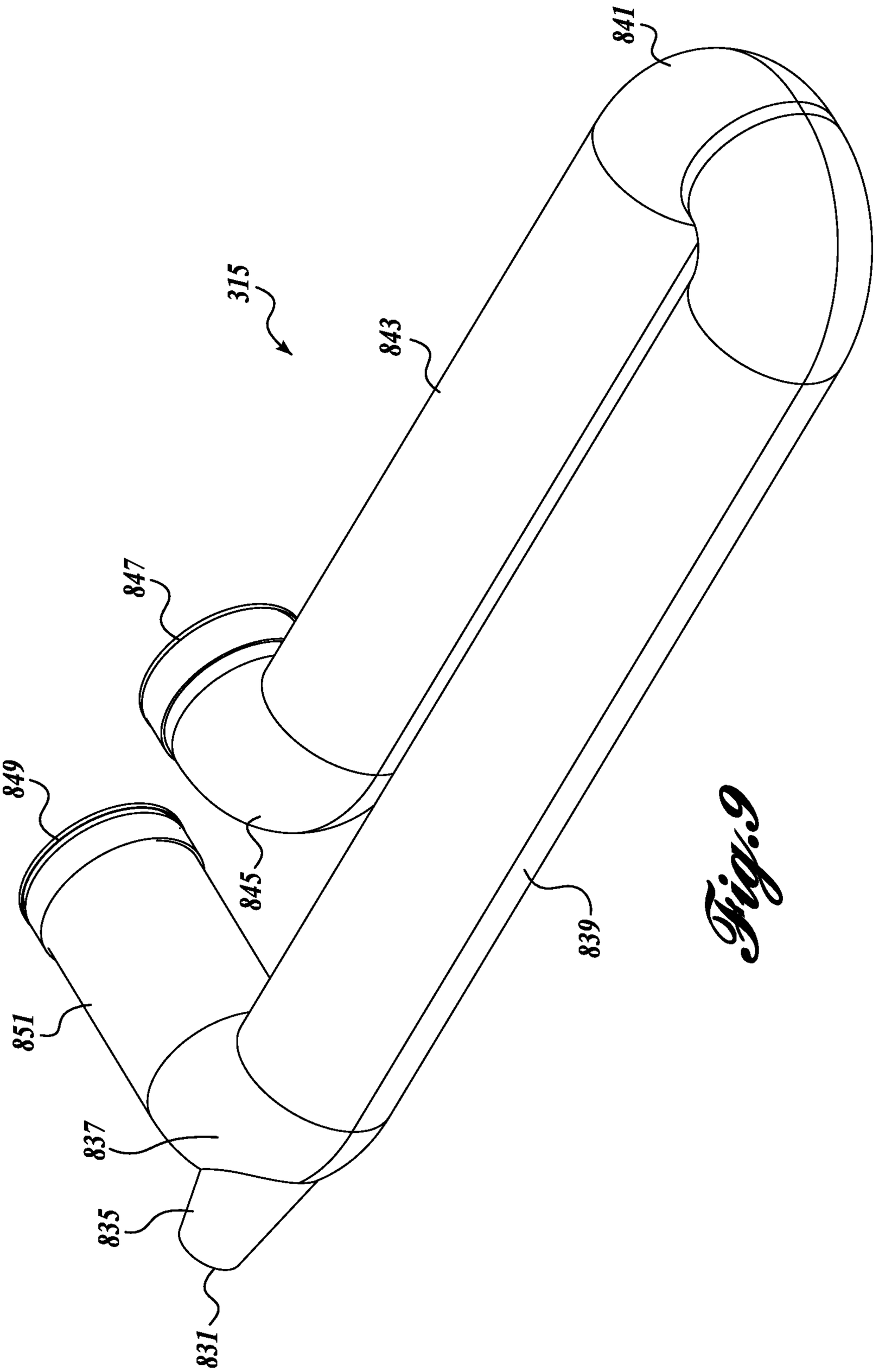
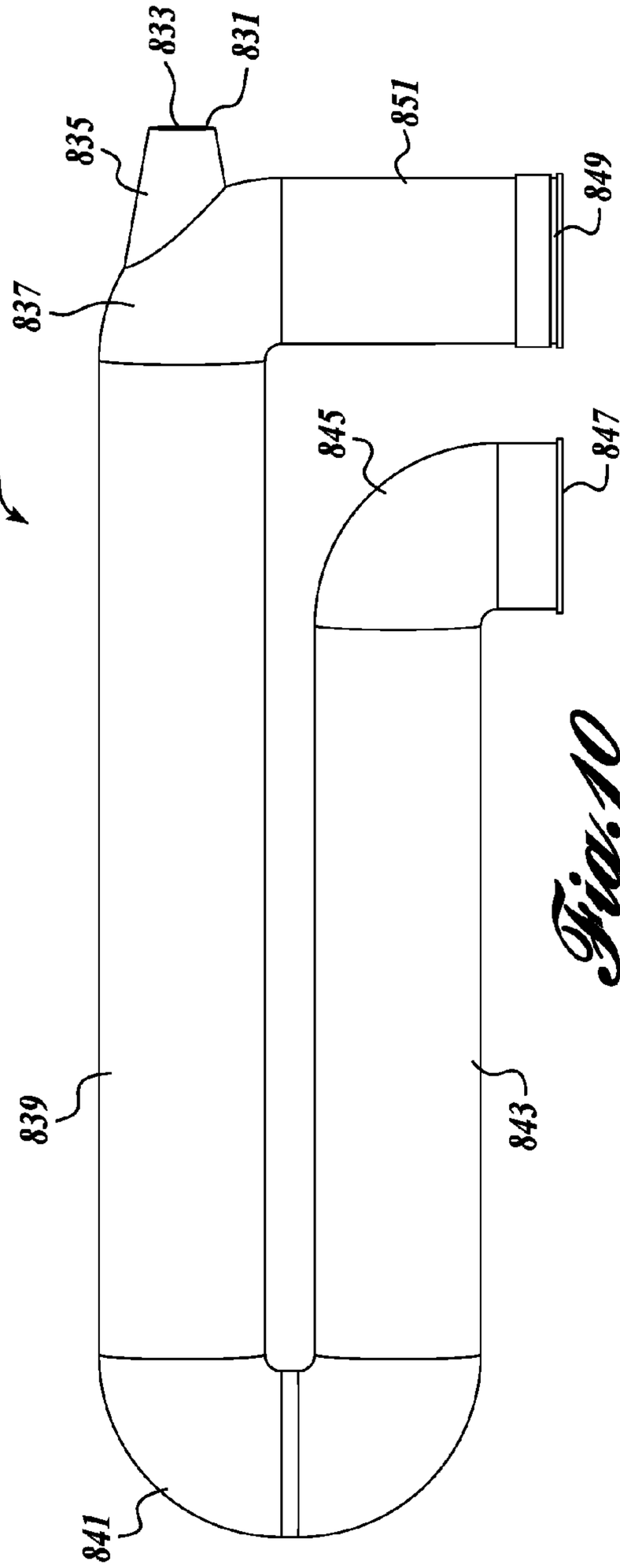


Fig. 9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837
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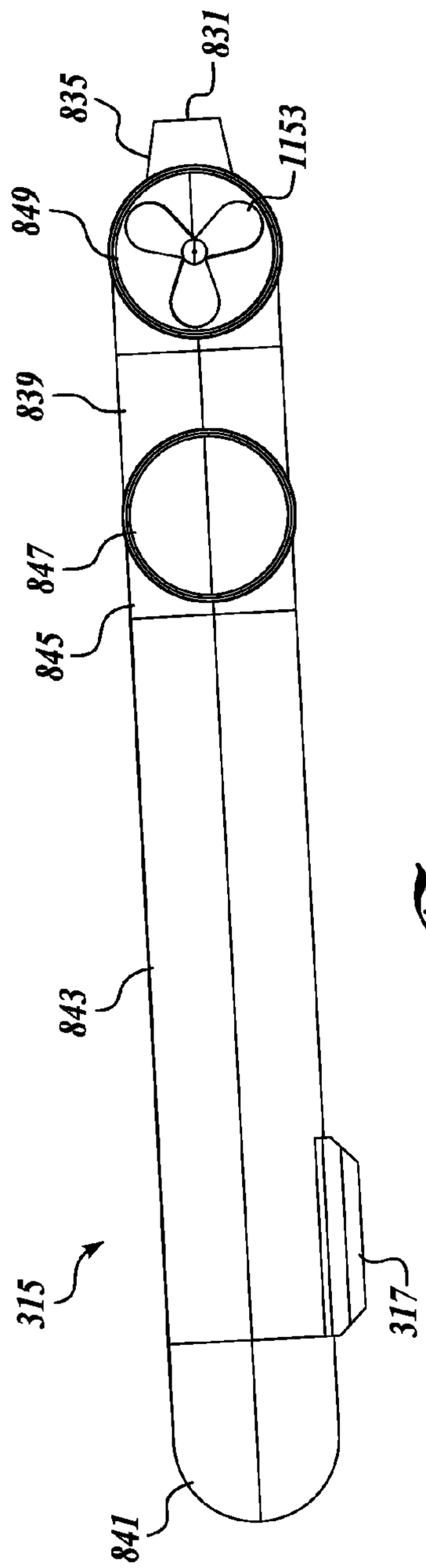
833
831
851
849
845
847
839
841
843

Fig. 10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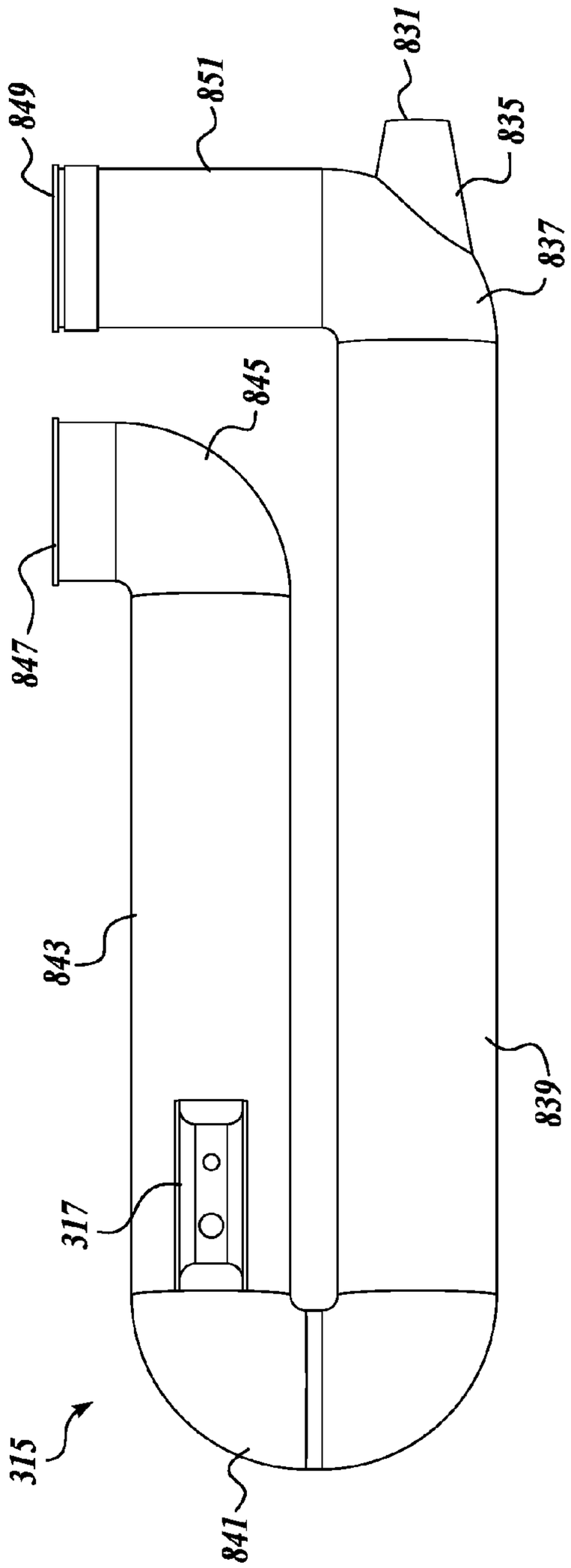
315
317
841

Fig. 11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315
841

Fig. 12

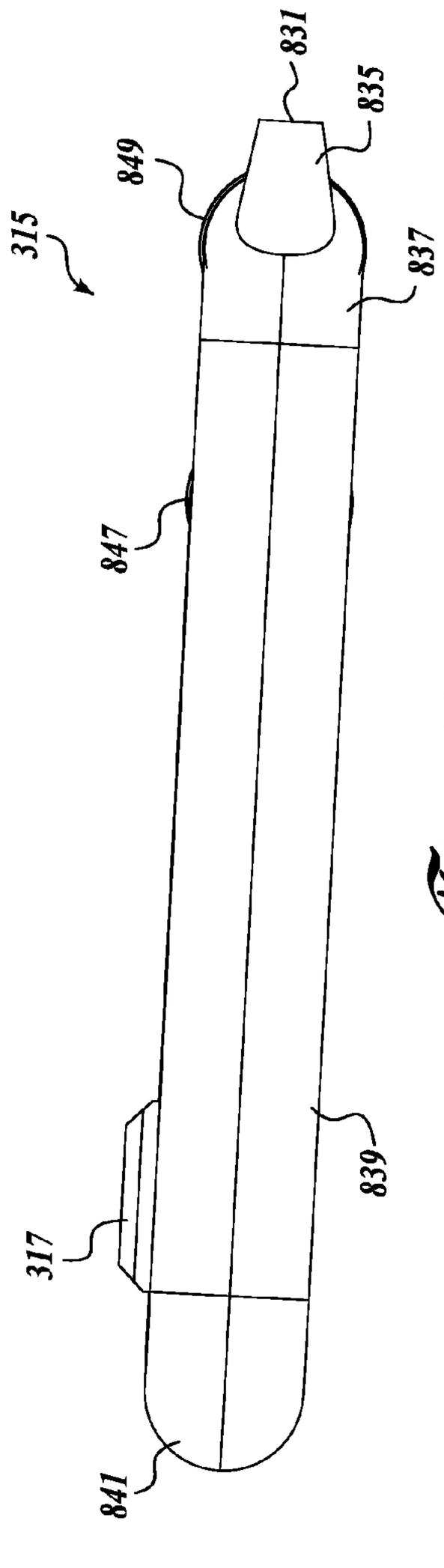
315
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Fig. 13

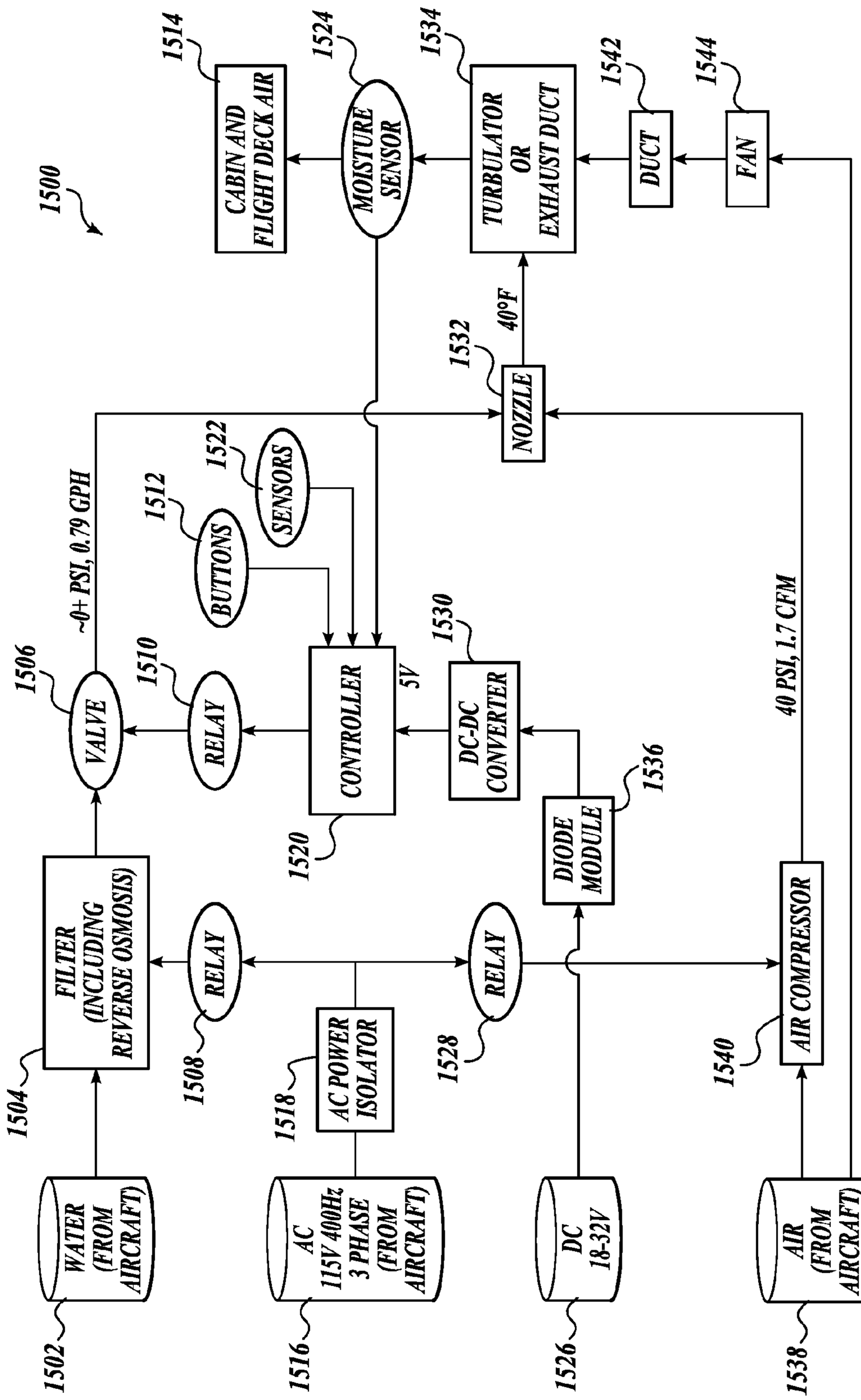
1500
1502
WATER (FROM AIRCRAFT)
1504
FILTER (INCLUDING REVERSE OSMOSIS)
1506
VALVE
~0+ PSI, 0.79 GPH
1508
RELAY
1510
RELAY
1512
BUTTONS
1514
CABIN AND FLIGHT DECK AIR
1516
AC 115V 400Hz 3 PHASE (FROM AIRCRAFT)
1518
AC POWER ISOLATOR
1520
CONTROLLER
1522
SENSORS
1524
MOISTURE SENSOR
1526
DC 18-32V
1528
RELAY
1530
DC-DC CONVERTER
5V
1532
NOZZLE
40°F
1534
TURBULATOR OR EXHAUST DUCT
1536
DIODE MODULE
1538
AIR (FROM AIRCRAFT)
1540
AIR COMPRESSOR
40 PSI, 1.7 CFM
1542
DUCT
1544
FAN

Fig. 14

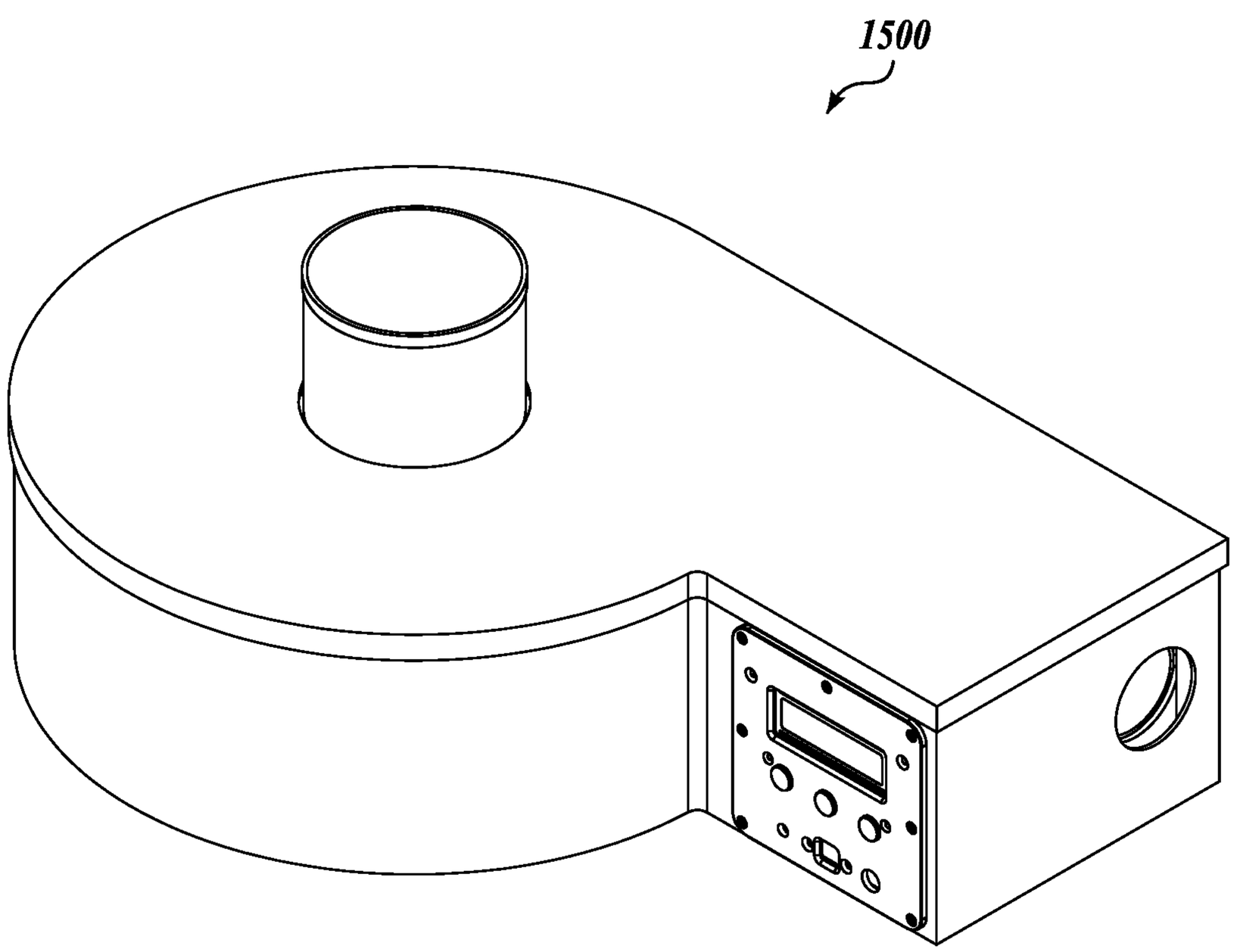

Fig. 15a

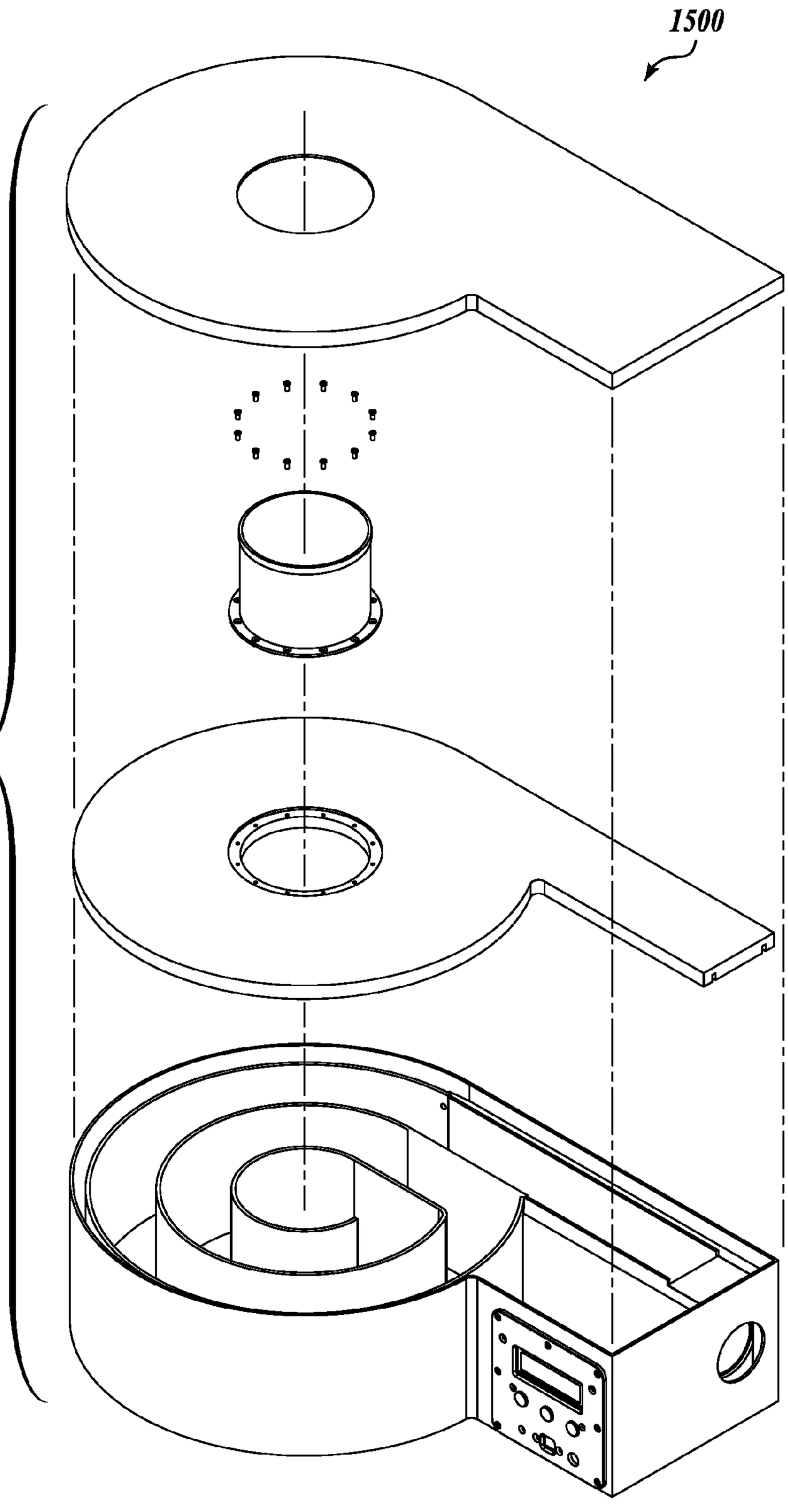

Fig. 15b

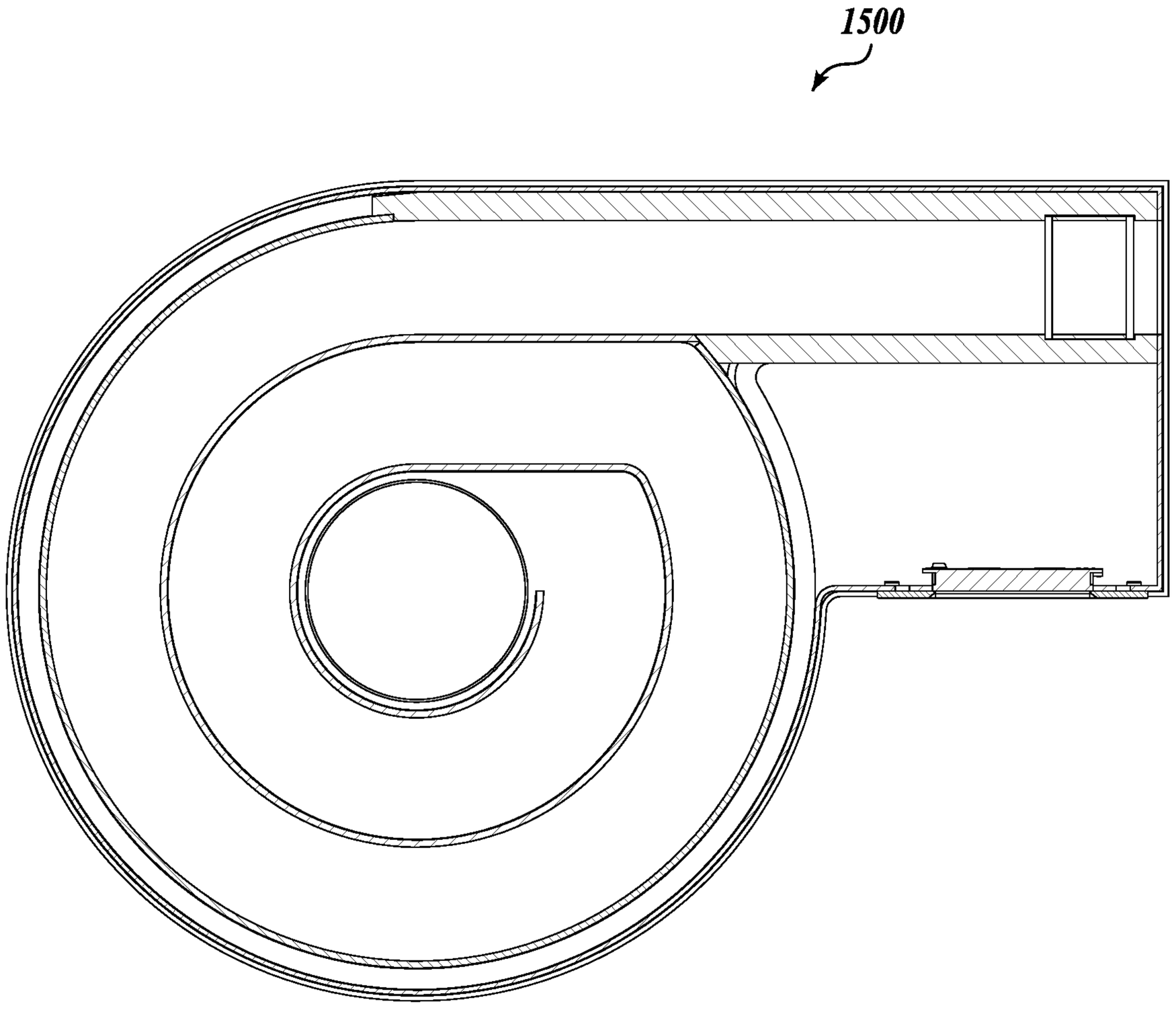

Fig. 15c

AIRCRAFT HUMIDIFIER

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Provisional Application No. 61/703,690, filed Sep. 20, 2012, which is incorporated herein by reference.

TECHNICAL FIELD

The present subject matter generally relates to aircraft environmental control systems, and more particularly, it relates to humidity control.

BACKGROUND

The environmental control system of an aircraft provides air supply, thermal control, and cabin pressurization for the crew and passengers. The atmosphere at typical jetliner cruising altitudes is generally very dry and cold, and outside air is pumped into the cabin on a long flight. Consequently, when humid air at lower altitudes is encountered and drawn in, the environmental control system dries it through the warming and cooling cycle, so that even with high external relative humidity, inside the cabin it will usually be not much higher than 10% relative humidity. Although low cabin humidity has health benefits such as preventing the growth of fungi and bacteria, the low humidity causes a drying of the skin, eyes, and mucosal membranes and contributes to dehydration, which leads to fatigue, discomfort, and health issues.

SUMMARY

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

One aspect of the present subject matter includes a device form which recites an aircraft humidifier comprising a water filtration system that is suitable to produce filtered water without freezing, the water filtration system operating by static water pressure from an aircraft and including stages selected from a group consisting essentially of reverse osmosis and deionization. The aircraft humidifier further comprises a duct that is capable of receiving atomized water droplets formed from the filtered water and compressed air to communicate the atomized water droplets to ambient air. The duct includes a mouth, throat, neck, and a mix joint to receive the atomized water droplets, which together communicate the atomized water droplets to a chute, C-joint, and canal, which together in turn communicate the atomized water droplets to the ambient air through a posterior air outlet while evaporating remaining atomized water droplets inside the duct.

Another aspect of the present subject matter includes a method form which recites a method for humidifying an aircraft cabin. The method comprises filtering water without freezing by operating static water pressure from an aircraft and producing filtered water by causing the water to enter stages of reverse osmosis, deionization, and final filtering. The method further comprises communicating atomized water droplets into ambient air through a duct that is capable of receiving atomized water droplets formed from the filtered water and compressed air while evaporating remaining atomized water droplets inside the duct.

DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a pictorial diagram illustrating an environment in which an archetypical aircraft humidifier operates in accordance with one embodiment of the present subject matter;

FIG. **2** is an isometric, perspective view illustrating an archetypical lidded aircraft humidifier in accordance with one embodiment of the present subject matter;

FIG. **3** is an isometric, perspective view of an archetypical unlidded aircraft humidifier assemblage in accordance with one embodiment of the present subject matter;

FIG. **4** is another isometric, perspective view of an archetypical aircraft humidifier assemblage in accordance with one embodiment of the present subject matter;

FIG. **5** is a further isometric, perspective view of an archetypical aircraft humidifier assemblage in accordance with one embodiment of the present subject matter;

FIG. **6** is a top plan view illustrating an archetypical aircraft humidifier assemblage in accordance with one embodiment of the present subject matter;

FIG. **7** is an additional isometric, perspective view of an archetypical aircraft humidifier assemblage in accordance with one embodiment of the present subject matter;

FIG. **8** is an isometric, front perspective view illustrating an archetypical duct in accordance with one embodiment of the present subject matter;

FIG. **9** is an isometric, back perspective view illustrating an archetypical duct in accordance with one embodiment of the present subject matter;

FIG. **10** is a top plan view illustrating an archetypical duct in accordance with one embodiment of the present subject matter;

FIG. **11** is a front view of an archetypical duct in accordance with one embodiment of the present subject matter;

FIG. **12** is a bottom plan view of an archetypical duct in accordance with one embodiment of the present subject matter;

FIG. **13** is a back view of an archetypical duct in accordance with one embodiment of the present subject matter;

FIG. **14** is a pictorial diagram illustrating an archetypical method for controlling an aircraft humidifier in accordance with one embodiment of the present subject matter;

FIG. **15***a* is an isometric, perspective view of an archetypical assembled duct **1500** in accordance with another embodiment of the present subject matter;

FIG. **15***b* is an isometric, exploded, perspective view of an archetypical unassembled duct **1500** in accordance with another embodiment of the present subject matter; and

FIG. **15***c* is a plan view of an archetypical duct **1500** in accordance with another embodiment of the present subject matter.

DETAILED DESCRIPTION

Various embodiments of the present subject matter engineer an aircraft humidifier. Some embodiments engineer a stand-alone, fully integrated aircraft humidifier that is suitable for providing uniform, non-wetting humidified air

disbursed by the aircraft humidifier into ambient air to increase the relative humidity in low humidity environments such as aircraft interiors, including cockpits, cabins, crew rests, cargo holds, and lavatories, as well as any other enclosed areas. The term "non-wetting" means the inclusion of a condition in which water is evaporated in air that is above the dew point. In many embodiments, the aircraft humidifier is engineered to include a water source, a supply of water, a water filter, compressed air, a specialized nozzle without moving parts, a duct (including, in some embodiments, a turbulator or an evaporator) to provide for maximum evaporation through the atomization of water, and an internal drainage and collection system to collect and recycle any loose un-evaporated water within the device to provide for a safe, sanitary and microbe-free environment. Depending on the interior aircraft dew point, in a few embodiments, it is engineered so that the produced humidification is not wetting to surfaces external to the aircraft humidifier by evaporating the water and the air, and surface temperatures are caused to be above the dew point of the humid air or vice versa.

FIG. **1** illustrates an aircraft cabin **100**, an environment in which an aircraft humidifier **103** operates. The aircraft humidifier is a device that is capable of improving breathing air quality by increasing relative humidity for the crew and/or the passengers in the aircraft cabin **100** including a locally delimited area and a region surrounding the locally delimited area. The aircraft cabin **100** is a section of an aircraft in which passengers lounge for traveling. At cruising altitudes of modern aircraft, the surrounding atmosphere is too thin for passengers and crew to breathe without an oxygen mask, so cabins are typically pressurized at a higher pressure than the ambient pressure at various altitudes.

In commercial air travel, particularly in airliners, cabins may be divided into several parts. These can include travel class sections in medium and large aircraft, areas for flight attendants, the galley, and storage for in-flight services. Seats are primarily arranged in rows and alleys. Along these alleys, an aircraft galley service trolley **102** may be pushed or pulled by flight attendants to facilitate in-flight services to passengers. In various embodiments of the present subject matter, the aircraft humidifier **103** is housed by the aircraft galley service trolley **102** so as to facilitate humidifying the aircraft cabin **100**. In a few embodiments, the aircraft humidifier **103** is suitably connected to an aircraft environmental control system (not shown) instead of being housed by the aircraft galley service trolley **102**.

FIG. **2** illustrates the aircraft humidifier **103** that is covered. In a few embodiments, the aircraft humidifier **103** is engineered so as to have a capacity to provide healthier air for passengers and crew. The aircraft humidifier **103** includes a lid **211** to protect the internal aircraft humidifier assemblage. A control jack **209** is provided on a side of the lid **211** to allow a remote controller **205** to connect to the control jack **209** so as to facilitate programming or controlling the aircraft humidifier **103** via a control wire **207**. In a few embodiments, the remote controller **205** interfaces with the aircraft humidifier **103** wirelessly, such as through Wi-Fi broadcasting in the aircraft cabin **100**.

FIGS. **3-7** illustrate the aircraft humidifier assemblage with the lid **211** removed. The aircraft humidifier assemblage includes a water filter system **322**. The water filter system **322** is coupled to a water source (not shown) to produce filtered water. In one embodiment, the water source is provided by a potable water supply on the aircraft; yet in another embodiment, the water source is a reservoir within the aircraft humidifier **103**. In one embodiment, the water filter system **322** is suitably a three-stage system that includes a reverse osmosis stage, a deionized stage, and a final filtration stage. In two or three embodiments, the three-stage system uses aircraft static water pressure to operate, but nothing else. In some embodiments, the holding tank is suitably not used. In a few embodiments, the water filter system **322** is engineered to facilitate antifreeze. A water feed line (not shown) communicates the filtered water to a valve **331**. The valve **331** is suitable for regulating the communication of filtered water to a nozzle **329**.

The aircraft humidifier assemblage includes a pressurized air tank **313**, which stores pressurized air. The aircraft humidifier assemblage includes a compressor **323** which is coupled to the pressurized air tank **313** to communicate pressurized air to be stored by the pressurized air tank **313**. A pressurized air feed line (not shown) communicates pressurized air to the nozzle **329**. In one embodiment, the compressor **323** is not used and instead the pressurized air tank **313** receives bled air from the aircraft. In another embodiment, the compressor **323** is not used and instead the pressurized air tank **313** receives compressed air from the aircraft. In a third embodiment, the compressor **323** is used to provide compressed air directly to the pressurized air feed line feeding the nozzle **329**.

The nozzle **329** is engineered for projecting venting, without moving parts, the filtered water communicated by the water feed line and the pressurized air communicated by the pressurized air feed line, in one embodiment, to produce atomized water droplets. In a second embodiment, the nozzle **329** is engineered to speed up, without moving parts, the filtered water communicated by the water feed line and the pressurized air communicated by the pressurized air feed line, to produce atomized water droplets. In a third embodiment, the nozzle **329** is engineered to accelerate the filtered water communicated by the water feed line and the pressurized air communicated by the pressurized air feed line, to produce atomized water droplets.

The atomized water droplets (or exhausted humidified air) are communicated by the nozzle **329** to a duct **315** (duct, turbulator duct, evaporator duct, exhaust duct, and mixing duct may be used interchangeably). The duct **315**, in one embodiment, is engineered to incorporate corrugated internal surfaces to agitate the evaporation of atomized water droplets. In a second embodiment, the duct **315** is engineered to facilitate a spiral curvilinear passage. In a third embodiment, the spiral curvilinear passage is suitably an expanding spiral. In a fourth embodiment, the spiral curvilinear passage is suitably a constant area spiral. In a fifth embodiment, the duct **315** is engineered to have variable side walls to minimize or maximize the rate of outflow. In almost all embodiments, the duct **315** is engineered to cause a further mixing of the air/water mixture in the form of atomized water droplets to ensure full evaporation.

A sump **317** is capable of collecting moisture leaking from the duct **315**. Any leaked moisture is detected and communicated by a sump moisture sensor **319**. Actual moisture in the sump **317** is communicated on a sump water recycle line **321** back to the water filter system **322**. An air inlet port **327***b* is provided by the aircraft humidifier assemblage to allow air to enter into the compressor **323**. The duct **315** is coupled to an air outlet port **325** as well as to an air inlet port **327***a*. The air outlet port **325** communicates the atomized water droplets to a locally delimited area of the aircraft cabin **100** and so as to feed humidified air into the locally delimited area of the aircraft cabin **100** during normal operation of the aircraft. In one embodiment, the atomized water droplets are communicated by the aircraft

humidifier **103** to ambient air without the use of the air outlet port **325**. In another embodiment, the atomized water droplets are communicated to the environmental control system of the aircraft, which in turn communicates the atomized water droplets to ambient air.

FIG. **7** illustrates the electronics portions of the aircraft humidifier assemblage in greater detail. The aircraft humidifier assemblage includes a DC-DC converter **723**, an AC power isolator **725**, a diode module **727**, a series of relays **729**, sensors (not shown), and solenoids (not shown). The DC-DC converter **723** converts DC voltage of the aircraft to a DC voltage that powers the remote controller **205**. The diode module **727** is a rectifier portion of a DC circuit (a combination of the aircraft's DC voltage source, the DC-DC converter **723**, and the diode module **727**), which acts to isolate the remote controller from the aircraft electrically. The AC power isolator **725** acts to isolate the alternating current source of the aircraft from those portions of the aircraft humidifier assemblage (e.g., the water filter system **322** and the compressor **323**).

FIGS. **8-13** illustrate the duct **315** in greater detail. The duct **315** includes a mouth **831** that has the capacity to receive the atomized water droplets from the nozzle **329**. The mouth forms a circular orifice that is larger than the diameter of a throat **833**. The atomized water droplets are communicated from the mouth **831** to the throat **833**, and then the atomized water droplets traverse through a neck **835**. The neck **835** is conical with its apex terminated at an angle. The neck **835** communicates the atomized water droplets to a mix joint **837**. Coupled to the mix joint **837** is a chute **839** through which the atomized water droplets are further communicated. The chute **839** is suitable for communicating the atomized water droplets longitudinally along its length to a C-joint **841**. The C-joint **841** communicates the atomized water droplets to a canal **843**. Coupled to the canal **843** is the sump **317** located at the bottom of the canal **843**. The canal **843** then communicates the atomized water droplets along its length, which is parallel to the chute **839** to a posterior joint **845** where the atomized water droplets exit through the posterior outlet **847**. Suitably, the posterior outlet **847** is an annular opening. The mix joint **837** is also coupled to an air cavity **851** which at its terminal is an anterior air inlet **849**. Suitably, the air cavity **851** is located perpendicularly to the chute **839** when fastened to the mix joint **837**. Inside the air cavity **851**, a fan **1153** is housed.

In one embodiment, the aircraft humidifier **103** is engineered to have a metallic or a composite liner which is water resistant and non-permeable to prevent leakage or contamination. In another embodiment, the aircraft humidifier **103** is engineered to include internal mechanisms to evaporate free water within the device. In a further embodiment, the aircraft humidifier **103** is engineered to recycle any free water within the device for deployment as humidification. In an additional embodiment, the aircraft humidifier **103** is engineered to facilitate access to internal components for maintenance, repair, and cleaning. In a concrete embodiment, the aircraft humidifier **103** is engineered to incorporate analog and/or digital controls for monitoring, switching, transmitting, metering, measuring, sensing, lighting, cleaning, and connecting to existing environmental control systems. In a specific embodiment, the aircraft humidifier **103** is engineered to be incorporated in a customized container which is the size of a typical aircraft galley service trolley and which then may be incorporated into the galley trolley insert locations with typical locking and docking mechanisms. In a latest embodiment, the aircraft humidifier **103** is engineered to include wheels or other mechanisms for mobility. In a latter embodiment, the aircraft humidifier **103** is engineered to be incorporated into the overhead storage bin of the aircraft's passenger cabin. In a latter embodiment, the aircraft humidifier **103** is engineered to be incorporated above or below the aircraft's passenger cabin. In an as yet further embodiment, the aircraft humidifier **103** is engineered to disperse disinfectants or other water soluble compounds into ambient air.

FIG. **14** illustrates an archetypical method **1500** for controlling an aircraft humidifier. A controller **1520** communicates with a relay **1510** to open or close a valve **1506** so as to allow water from an aircraft **1502** which has been filtered by a filter **1504** (which is capable of reverse osmosis, deionization, and so on) to the valve **1506** so as to enter a nozzle **1532**. A voltage source **1516**, which in one embodiment is alternating current rated at 115 volt, 400 hertz, 3-phase from the aircraft, is coupled to an AC power isolator **1518**. The power coming out from the AC power isolator **1518** is communicated to a relay **1508** to control the filter **1504** and a relay **1528** to control an air compressor **1540**. A direct current power source **1526** of approximately 18-32 volts is communicated to a diode module **1536**. The diode module **1536** acts to rectify the power coming from the DC voltage source **1526** and communicates the power to a DC-DC converter **1530**. The converted power is presented to the controller **1520** to power it. Air source **1538** is provided by the aircraft and is provided to both the air compressor **1540** as well as to a fan **1544**. The air compressor **1540** compresses the air from the air source **1538** and presents the compressed air to the nozzle **1532**. The resultant air product (in the form of atomized water droplets) coming from the nozzle **1532** is presented to a turbulator or exhaust duct **1534**. The fan **1544** also conducts air through a duct **1542** and also to the turbulator or exhaust duct **1534**. The air moves through a moisture sensor **1524**, which communicates its findings back to the controller **1520** and permits the air to enter the cabin and flight deck air **1514**. The method **1500** supplies humidified air into the aircraft cabin **100**, including a locally delimited area and a region surrounding the locally delimited area. The method **1500** humidifies the air with a water source. The method **1500** then feeds the humidified air at the first partial pressure through a feed line into the locally delimited area during normal operation of the aircraft. The first partial pressure is higher than a second oxygen partial pressure in the region surrounding the locally delimited area.

While illustrative embodiments have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

The invention claimed is:

1. A system comprising:

an aircraft humidifier comprising:

a water filtration system that is suitable to produce filtered water without freezing, the water filtration system operating by static water pressure from an aircraft and including stages selected from a group consisting essentially of reverse osmosis and deionization; and

a duct that is capable of receiving atomized water droplets formed from the filtered water and compressed air to communicate the atomized water droplets to ambient air, the duct including a mouth, throat, neck, and a mix joint to receive the atomized water droplets, which together communicate the atomized water droplets to a chute, C-joint, and canal, which together in turn communicate the atomized water

droplets to the ambient air through a posterior air outlet while evaporating remaining atomized water droplets inside the duct; and

an aircraft galley service trolley on wheels in which the aircraft humidifier is housed.

2. The aircraft humidifier of claim **1**, wherein the duct further includes an air cavity and an anterior air inlet, which communicates air through the air cavity into the mix joint, the air cavity including a fan.

3. The aircraft humidifier of claim **2**, further comprising a compressor which compresses air to produce the compressed air.

4. The aircraft humidifier of claim **3**, further comprising a pressurized air tank for storing the compressed air produced by the compressor.

5. The aircraft humidifier of claim **4**, further comprising a valve which has a capacity to receive the filtered water and communicate the filtered water.

6. The aircraft humidifier of claim **5**, further comprising a nozzle which is suitable for receiving the filtered water from the valve and the compressed air from the compressor, the nozzle communicating the atomized water droplets to the duct.

7. The aircraft humidifier of claim **6**, further comprising a sump coupled to the duct, which is capable of collecting moisture leaking from the duct.

8. The aircraft humidifier of claim **7**, further comprising a sump moisture sensor coupled to the sump, which has a capacity to detect moisture and communicate such a detection.

9. The aircraft humidifier of claim **8**, further comprising a water recycle line coupled to the sump, which is suitable for communicating moisture from the sump back to the water filter system.

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